REMARKS

Claims 1-3, 6-11, 13-16, and 20-25 are pending in the present application. By the present Communication, no claims have been added, canceled, or amended. Accordingly, upon entry of the present amendment, claims 1-3, 6-11, 13-16, and 20-25 remain under consideration.

Rejections under 35 U.S.C. §102

Applicant respectfully traverses the rejection of claims 1-3, 6-11, and 13 under 35 U.S.C. §102(b), as allegedly being anticipated by Leal *et al.* (*Inorganica Chimica Acta* 240: 183-189, 1993; hereinafter "Leal"). To anticipate, a single reference must inherently or expressly teach each and every element of claimed invention. *In re Spada*, 15 USPQ2d 1655 (Fed Cir. 1990); and *Verdegaal Bros. v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). M.P.E.P. § 2131.

The Office Action alleges that Leal discloses an amine-functionalized mesoporous silica with covalently bound amines with an adsorption capacity of 10 cc/g at STP. Applicant respectfully submits that Leal grafted 3-aminopropyltriethoxysilane (APTES) on the surface of silica gel (Leal, page 185, right column) with ill-defined pore structure. According to Leal, "[a]dsorption experiments on different preparations of the material on the flow apparatus previous described resulted in an adsorptive capacity of 9.10 ± 0.05 cc/g of dry CO_2...." (Leal, page 186, right column). As such, Applicant submits that Leal's material adsorbed only 9.1 cc/g (or 0.4 mmol/g) at 1 atm of pure CO_2.

Applying the same to ordered mesoporous silicas leads to unexpectedly vastly different material. Under the same adsorption conditions, MCM-41 grafted with APTES showed exemplary CO_2 adsorption capacities of 11.7 to 14.4 cc/g and 11.19 / 19.31 cc/g (see, Tables 3 and 4 of the specification as filed). In view of the significantly improved adsorption characteristics of the claimed ordered mesoporous silicas, Applicant respectfully submits that Leal does not anticipate the claimed invention. Withdrawal of the rejection is respectfully requested.

Rejections under 35 U.S.C. §103

Applicant respectfully traverses the rejection of claims 1-3, 6, 8-11, 13-16, and 20-24 under 35 U.S.C. §103(a) as allegedly being unpatentable over Birbara, *et al.* (U.S. Pat. No. 5,876,488; hereinafter, "Birbara") in view of Stein, *et al.* (*Advanced Materials* 12(19) p. 1403-1419, 2000; hereinafter, "Stein"). The U.S. Supreme Court decision in the *KSR International v. Teleflex, Inc.* (82 USPQ2d 1385), modified the standard for establishing a *prima facie* case of obviousness. Under the *KSR* rule, three basic criteria are considered. First, some suggestion or motivation to modify a reference or to combine the teachings of multiple references still has to be shown. Second, the combination has to suggest a reasonable expectation of success. Third, the prior art reference or combination has to teach or suggest all of the recited claim limitations. Factors such as the general state of the art and common sense may be considered when determining the feasibility of modifying and/or combining references. Applicant respectfully submits that the criteria for establishing a *prima facie* case of obviousness have not been satisfied.

The Office Action alleges that Birbara teaches a mesoporous material with an amine-functionalized surface for use as a reusable carbon dioxide adsorbent. However, the Office Action admits that Birbara does not teach the use of mesoporous silica. The Office Action relies upon Stein for allegedly teaching that the surface of mesoporous silicas may be functionalized with amines through a known grafting process and that functionalized mesoporous silica is useful as an adsorbent. According to the Office Action, it would have been obvious to a worker skilled in the art to use any porous support fitting the requirements of Birbara ("a porous material with high surface area that is readily functionalizable with useful amines") with a reasonable expectation of success. In the alternative, the Office Action suggests that Stein indicates that mesoporous silica is particularly useful for its readily tunable pore diameters and that pore diameter has been recognized as a factor in adsorption performance. Based on this, the Office Action asserts that it would have been obvious to one of ordinary skill in the art to use mesoporous silica in Birbara's adsorption device in order to allow fine-tuning of the pore diameter for maximum performance.

Applicant respectfully submits that framework functionalized mesoporous organosilica as depicted in Fig. 7 (Claims 1, 2, 7, 25) is fundamentally different from surface modification. It

therefore would not have been obvious to one of ordinary skill in the art at the time of the present application to derive such structures based on any of the Birbara or Stein teachings.

Stein and Birbara do not teach the use of organosilica and framework modified organosilica for the purpose of CO_2 capture. As depicted in Fig. 7, organosilica are fundamentally different from silica as the organic moieties are an integral part of the material backbone. Modifying the organic spacers with amine groups at the precursor level (*i.e.*, before self-assembly of the material) or in the already self-assembled mesoporous organosilica (Fig. 7) is not taught nor suggested by Stein or Birbara.

While surface grafting is known in the art for the preparation of surface modified silica beads for liquid chromatography separation, Applicant respectfully submits that combining surface grafting with the type of periodic mesoporous silica described in Table 1 and Fig. 1 led to unexpectedly high CO_2 uptake, compared to surface grafting onto common amorphous silica gels. The local environment with the silica pore channels give rise to enhanced reactivity of amine groups and higher CO_2 adsorption per amine group (CO_2/N). Even within the family of mesoporous silicas, this enhancement is pore-size dependent. As such, the overall CO_2 removal capacity depends on the total surface area of the support. However, it would not have been obvious to a person of ordinary skill in the art that the CO_2/N ratio is dependent on pore size and pore system. Thus, Applicant submits that the combination of surface grafting with the specific pore structure of ordered mesoporous silicas leads to unexpectedly higher CO_2/N ratios.

Birbara describes a CO_2 adsorbent that is prepared by simple mixing of a commercially available polymeric support with an alcoholic solution of an amine-containing substance followed by elimination of the solvent by evaporation (Biraba, column 3, lines 48-61). These amine-containing substances would have been known for removing CO_2 by absorption when they are used in solution.

Applicant notes that the supports described by Birbara are mostly microporous, not mesoporous (alumina, zeolites, carbon molecular sieves) (see, *e.g.*, column 3, lines 34-36). While the actual support used by Birbara may have had an average pore size that falls into the mesopore range (80 angstrom), this kind of polymer (Amberlite) is known to be comprised of a network of pores with very broad size distribution, making the "average pore size" meaningless. This pore

system is far removed from the well-ordered pore systems of the mesoporous silicas reported in Table 1 and Fig. 1.

Birbara requires a support that "*possess surface characteristics which promote adhesion of the amine to the support by chemical bonding*" (see, column 3, lines 45-47). Silica does not meet this criteria, as no chemical bonding between the silica surface and the proposed amines will occur. The high content of amine-containing substance (above 50 wt%) is likely to give rise to complete pore filling, thus to excessive diffusion resistance leading to low rate of adsorption. In addition, this type of adsorbent suffers gradual loss of active species by evaporation. To mitigate this problem, Birbara suggested to regenerate the material at 50°C (column 4, line 59). This temperature is unrealistically low, as the actual temperature of adsorption which starts at 30°C may very well reach 50°C because the CO_2 adsorption is highly exothermic (releases heat).

Applicant respectfully submits that Birbara uses the support in commercially available pellets or beads before amine impregnation. Birbara does not teach making pellets out of adsorbent power (present Claims 23-24).

Based on Birbara, Applicant respectfully submits that it would not have been obvious to one of ordinary skill in the art at the time of the present application to combine the following: (i) use of a different support that does not meet the surface polarity requirement (column 3, lines 34-35) such as silica, (ii) use of different amine-containing molecules (*i.e.*, aminosilanaes vs. hydroxyamines), and (iii) use of a different bonding strategy (*i.e.*, grafting vs. impregnation). In sum, Applicant respectfully submits that Birbara neither teaches nor suggests the combination of a support which is a mesoporous silica or organosilicate with narrow pore size distribution prepared by supramolecular templating technique, which is functionalized via covalent attachment of compounds containing acid gas-reactive functional groups within the pores or framework of said support.

With regard to Stein, Applicant submits that it would have been counterproductive to use mesoporous silicas or organosilicas and fill their pores with amine-containing molecules according to Birbara's procedure. Stein describes the use of mesoporous silica made hydrophobic via surface modification by small organic species such as phenyl, trimethyl or vinyl groups, and their use to remove other hydrophobic pollutants from mixtures with air or water (Section 4.2.4). Further, Stein teaches the use of surface hydrophobicity for the separation of hydrophobic pollutants.

In summary, the present invention is directed to a unique surface hydrophobicity for withholding facilitating the dispersion of amine-containing molecules. The actual CO_2 removal has nothing to do with the surface hydrophobicity. As such, the approach utilized by the inventors eliminates the diffusion problems associated with Birbara's pore filling procedure. Further, regular silicas such as the silica gel used by Leal are not hydrophobic. Xylene was to dissolve the amine-containing substance, rather than to explore the wettability of silica.

Applicant respectfully submits that Biraba, when considered alone or in combination with Stein, does not teach or suggest Applicant's claimed adsorbent. Absent such a teaching or suggestion, Biraba, alone or in combination with Stein, cannot render the claimed invention obvious. Accordingly, Applicant respectfully requests reconsideration and withdrawal of this rejection.

Applicant respectfully traverses the rejection of claims 7, 20, and 25 under 35 U.S.C. §103(a) as allegedly being unpatentable over Birbara in view of Stein, as provided above, and further in view of Sayari. The arguments set forth above with regard to Biraba and Stein apply equally and are incorporated here. The Office Action alleges that Sayari teaches that organosilica provides superior structure control to that of the other mesoporous silicas. As provided above, the approach utilized by the inventors eliminates the diffusion problems associated with Birbara's pore filling procedure. Further, regular silicas such as the silica gel used by Sayari are not hydrophobic. Accordingly, Applicant respectfully submits that Biraba, when considered alone or in combination with Stein and Sayari, does not teach or suggest Applicant's claimed adsorbent. Absent such a teaching or suggestion, Biraba, alone or in combination with Stein and Sayari, cannot render the claimed invention obvious. Accordingly, Applicant respectfully requests reconsideration and withdrawal of this rejection.

CONCLUSION

In view of the amendments and above remarks, it is submitted that the claims are in condition for allowance, and a notice to that effect is respectfully requested. The Examiner is invited to contact Applicant's undersigned representative if there are any questions relating to this application.

The Commissioner is hereby authorized to charge $650.00 as payment for the Two-Month Extension of Time fee ($245) and the Request for Continued Examination fee ($405) to Deposit Account No. 07-1896. No other fees are believed to be due in connection with the filing of this paper. However, the Commissioner is hereby authorized to charge any other fees that may be due in connection with the filing of this paper, or credit any overpayment to Deposit Account No. 07-1896.

Respectfully submitted,

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